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Segmental Reversal of the Small Bowel as an Alternative to Intestinal Transplantation in Patients With Short Bowel Syndrome

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Objective
This article reports the results of segmental reversal of the small bowel on parenteral nutrition dependency in patients with very short bowel syndrome.

Summary Background Data
Segmental reversal of the small bowel could be seen as an acceptable alternative to intestinal transplantation in patients with very short bowel syndrome deemed to be dependent on home parenteral nutrition.

Methods
Eight patients with short bowel syndrome underwent, at the time of intestinal continuity restoration, a segmental reversal of the distal (n = 7) or proximal (n = 1) small bowel. The median length of the remnant small bowel was 40 cm (range, 25 to 70 cm), including a median length of reversed segment of 12 cm (range, 8 to 15 cm). Five patients presented with jejunotransverse anastomosis, and one each with jejunorectal, jejuno left colonic, or jejunocaecal anastomosis with left colostomy.

Results
There were no postoperative deaths. Three patients were reoperated early for wound dehiscence, acute cholecystitis, and sepsis of unknown origin. Three patients experienced transient intestinal obstruction, which was treated conservatively. Median follow-up was 35 months (range, 2 to 108 months). One patient died of pulmonary embolism 7 months postoperatively. By the end of follow-up, three patients were on 100% oral nutrition, one had fluid and electrolyte infusions only, and, in the four other patients, parenteral nutrition regimen was reduced to four (range of 3 to 5) cyclic nocturnal infusions per week. Parenteral nutrition cessation was obtained in 3 of 5 patients at 1 year and in 3 of 3 patients at 4 years.

Conclusion
Segmental reversal of the small bowel could be proposed as an alternative to intestinal transplantation in patients with short bowel syndrome before the possible occurrence of

parenteral nutrition-related complications, because weaning from parenteral nutrition (four patients) or reduction of the frequency of infusions (four patients) was observed in the current study.

Short bowel syndrome (SBS) caused by extensive resection of the small bowel results in diarrhea and malabsorption. In SBS patients, although of modest importance, adaptation of the remnant bowel is generally observed within months of resection. However, many patients with SBS may remain indefinitely dependent on parenteral nutrition, especially those with <1 m of remnant small bowel, without either the ileocolonic junction or the remnant colon.[1]

Although long-term survival is possible in SBS patients requiring home parenteral nutrition (HPN), with a 75% 5-year probability of survival[2] its cost and morbidity rate have resulted in an interest in developing surgical alternatives to HPN. Since the introduction of the new immunosuppressant FK506, intestinal transplantation has garnered interest in clinical practice. Actuarial patient and primary graft survival rates at 2 years are still approximately 60 and 50%, respectively,[3] making transplantation a challenge.

Nontransplant surgical options for SBS include tapering (i.e., reduction of the circumference of the intestine by either imbrication or excision of redundant bowel wall along the antimesenteric border), lengthening (longitudinal transection of the intestine between the mesenteric and antimesenteric edges and anastomosis of these parallel intestinal segments), artificial intestinal valve construction (distal intussusception of a segment of small intestine), colonic interposition, and segmental reversal of the small bowel (SRSB).[1] Because tapering and lengthening can only be performed in a dilated bowel and an artificial intestinal valve construction constitutes a difficult surgical procedure, we believed that SRSB could be seen as an acceptable alternative to intestinal transplantation in patients with SBS deemed to be dependent on HPN. Since the first description of SRSB in humans, only a few anecdotal reports have been published, and most of these only included one or two cases dating back to the 1960s,[1,4–13] i.e., before the development of HPN.

We report here our technique of SRSB in eight adult patients with very small bowel syndrome with respect to parenteral nutrition dependency.

PATIENTS AND METHODS

Patients

From 1985 to 1995, eight patients with SBS underwent SRSB. Before SRSB operation, all but one of the patients were followed at the approved center for HPN in Saint-Lazare Hospital, and all but two underwent SRSB at the Lariboisière Hospital, both belonging to Paris University.

The clinical findings for the eight patients are given in Table 1. There were 5 men and 3 women, whose mean age was 58 ± 16 years (range, 34 to 71 years).

Before SRSB, all patients except one were totally dependent on HPN, 7 days a week, for a range of 2 to 12 months (4 ± 3 months, mean ± SD). SBS was secondary to extensive bowel resection for mesenteric infarction in four patients, and for radiation enteritis, gunshot, and postoperative fistula in one case each. In all these patients, subtotal enterectomy was performed elsewhere, and then the patients were later referred to our tertiary care center for HPN and SRSB. The eighth patient with familial adenomatous polyposis had 100% oral nutrition before SRSB. He presented with intestinal occlusion secondary to desmoid tumor and underwent, simultaneously, subtotal enterectomy and SRSB, before being included in our HPN program.

At our institution, SRSB was considered for SBS patients in whom the three following conditions were present: a postduodenal small bowel remnant of <1 m, an absence of the ileocolonic junction, and an indication for reestablishment of jejunocolic continuity.

Operative Procedure

Before SRSB, mean length of the remnant small bowel, measured intraoperatively, was 46 ± 18 cm (range, 25 to 70 cm). The ileocolonic junction had been effectively removed in all patients. One patient had no remaining colon, but the other seven had a partial colectomy only: in five cases it was right colon, in one case, right + transverse colon, and in one, right + transverse colon with terminal left colostomy.

The first step of SRSB consisted of preparing a short segment of the distal remnant small bowel. In one patient, a proximal instead of a distal segment was reversed for technical reasons. The mean length of the segment used for SRSB was 12.7 ± 2.8 cm (range, 8 to 15 cm). Briefly, it was separated from the remaining small bowel, leaving its blood supply intact, and then reversed. Next, the segment was reanastomosed, proximally to the remaining small bowel and distally to the remaining colon (Fig. 1). Complete 360° mesenteric rotation was avoided by correct positioning of the proximal and distal parts of the intestine before anastomosis (roration of both segments was ~90°).

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Table 1. CLINICAL FINDINGS AND PREOPERATIVE INTESTINAL STATUS IN EIGHT PATIENTS HAVING UNDERGONE SEGMENTAL REVERSAL OF THE SMALL BOWEL FOR SHORT BOWEL SYNDROME

Patient No.	Age (yr)/Sex	Etiology of Short Bowel	Operations Before Reversed Segment	Intestinal Status Before Reversed Segment (length of remnant small bowel)	Parenteral Nutrition Dependence Before Reversed Segment (duration)
1	34/M	Gunshot	9/85: duodenal suture + bowel resection Day 6: subtotal enterectomy + right and transverse colectomy Day 23: iterative jejunal resection	Jejunostomy (60 cm) Left colostomy	7 days/week (3 mo)
2	58/M	Mesenteric infarction	10/89: embolectomy (superior mesenteric artery) Day 1: subtotal enterectomy + right colectomy	Jejunostomy (25 cm) Transverse colon close into the abdomen	7 days/week (4 mo)
3	34/M	Desmoid tumor	9/85: total colectomy + ileorectal anastomosis 6/90: explorative laparotomy	Ileorectal anastomosis	No parenteral nutrition*
4	70/F	Mesenteric infarction	8/92: subtotal enterectomy + right colectomy	Jejunostomy (30 cm) Transverse colon close into the abdomen	7 days/week (4 mo)
5	71/M	Postoperative fistula	1/92: appendicectomy Day 13: right colectomy + enterectomy (1 m) Day 23: subtotal enterectomy Day 27: explorative laparotomy	Jejunostomy (70 cm) Transverse colostomy	7 days/week (12 mo)
6	70/F	Radiation enteritis	9/93: subtotal enterectomy 10/93: intra-abdominal abscess	Jejunostomy (60 cm) and end ileostomy Transverse stenosis; radiation proctitis	7 days/week (3 mo)
7	58/M	Mestenteric infarction	11/94: embolectomy (superior mesenteric artery) Day 1: subtotal enterectomy + cecectomy	Jejunotransverse anastomosis (25 cm)	7 days/week (3 mo)
8	67/F	Mesenteric infarction	9/95: embolectomy (superior mesenteric artery) + partial enterectomy + right colectomy Day 2: subtotal enterectomy	Jejunostomy (40 cm) Transverse colostomy	7 days/week (2 mo)

* Patient operated for desmoid tumor undergoing simultaneously subtotal enterectomy and reversed segment.

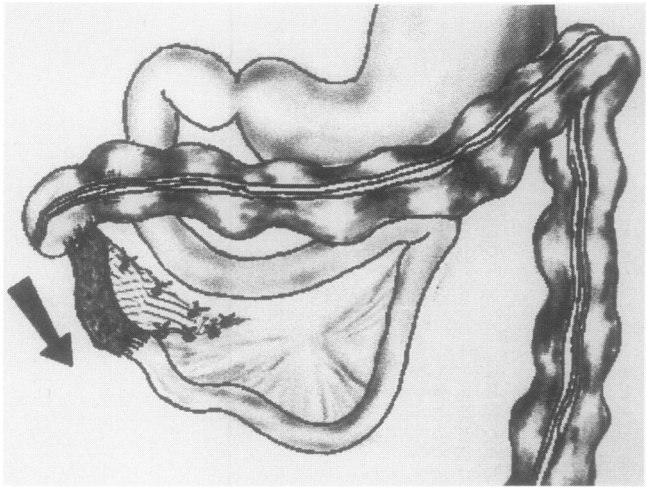

Figure 1. SRSB with jejunotransverse anastomosis in a patient with SBS. SRSB = segmental reversal of the small bowel; SBS = short bowel syndrome.

This meant that the necessary mesenteric rotation of the reversed segment was only ~180°.

After SRSB had been completed, anastomosis was jejunotransverse in five patients and jejunorectal, jejuno left colonic, or jejunocecal with left colostomy in one each.

During the entire follow-up, patients were placed on free oral diet and were encouraged to eat as much as they could.[14]

RESULTS

Postoperative Morbidity and Mortality

There were no postoperative deaths. The nasogastric suction tube was removed after a median of 5 days (range, 2 to 7 days).

One patient (patient 4) was reoperated on day 2 for sepsis of unknown origin. Laparotomy was not contributive. One patient (patient 5) experienced pulmonary infection requiring parenteral antibiotics. One patient (patient 8) experienced wound dehiscence on postoperative day 4. She was reoperated with an uneventful postoperative course. Another patient (patient 1) was reoperated on day 21 for acute acalculous cholecystitis. Two patients (patients 3 and 4) experienced transient intestinal obstruction 1 month after surgery and were treated conservatively.

The mean duration of hospital stay was 18 ± 8 days (range, 10 to 36 days) in the surgical unit and was subsequently 34 ± 4 days (range, 28 to 39 days) in the nutrition gastroenterology unit.

Long-Term Results

The median follow-up period was 35 months (range, 2 to 108) (Table 2).

Patient 6 died of pulmonary embolism at 7 months after operation. At the time of death, HPN had been reduced from 7 to 3 days/week.

Patient 1 experienced, at 5 months and 6 years postoperatively, attacks of transient intestinal obstruction partly due to Ca, K, and Mg blood disturbances and to loperamide abuse, and was successfully treated conservatively with both oral vitamin D and intramuscular mineral supplements.

By the end of follow-up, four patients were weaned from HPN (50%) (patients 1 to 3, and 5). In three of them (37.5%), HPN was definitely stopped 3, 7, and 9 months, respectively, after the SRSB procedure, and normal nutritional status was maintained under 100% oral nutrition until the end of follow-up, 108, 67, and 26 months, respectively (patients 1, 2, and 5). The length of the remnant small bowel (including the reversed segment) in these three patients was 60, 25, and 70 cm, respectively. In the fourth HPN-weaned patient (patient 3), where SRSB was done on a rectal anastomosis (no colon remaining), HPN was stopped 41 months postoperatively, but he needed, until his 51 month of follow-up, 2 L of fluid and electrolyte infusions at the rate of 2 to 4 days/week.

For the four other patients (patients 4, and 6 to 8), the rate of HPN delivery was reduced from 7 to 4 days per week (range, 3 to 5 days). In three of them (patients 6 to 8), follow-up was <9 months. In the last one (patient 4), follow-up was 35 months, but in this patient a proximal instead of a distal SRSB had been performed. Persistent and permanent nausea in this patient has resulted in superimposed depression. He was the only patient of the current study in whom oral hyperphagic feeding was not observed (i.e., more than twice the basal energy need of the patient).[14]

Finally, the actuarial rate of weaning-off HPN (Fig. 2) was 3 of 5 patients, 2 of 3 patients, and 3 of 3 patients after 1, 3, and 4 years, respectively.

DISCUSSION

The management of SBS requires long-term nutritional support, high dosages of antidiarrheal drugs, and occasionally additional surgical procedures.[15] After massive small bowel resection in adults, definitive HPN can be anticipated if the postduodenal length of the remaining small bowel is <60 to 80 cm, and there is absence of the ileocolonic junction[16] and a partial colonic resection.[17] This study suggests that SRSB could be safely proposed for patients with a very short remnant small bowel requiring definitive HPN. Despite a significant morbidity rate, no mortality was observed in our patients, and SRSB allowed 50% of them to be free of HPN.

The development of HPN[2] and alternative treatments, including intestinal transplantation,[3] has revolutionized

Table 2. SURGICAL PROCEDURE AND POSTOPERATIVE INTESTINAL STATUS IN EIGHT PATIENTS HAVING UNDERGONE SEGMENTAL REVERSAL OF THE SMALL BOWEL FOR SHORT BOWEL SYNDROME

Patient No.	Date of Operation	Intestinal Status After Reversed Segment (length of remnant small bowel including reversed segment)	Length of Reversed Segment (cm) (location on the remnant small bowel)	Follow-up Duration (mo)	Parenteral Nutrition Dependence at the End of Follow-up
1	12/3/85	Jejuno-left colonic anastomosis (60 cm)	15 (distal)	108	No (HPN stopped 2/86; 100% oral nutrition)
2	2/27/90	Jejunotransverse anastomosis (25 cm)	15 (distal)	67	No (HPN stopped 11/90; 100% oral nutrition)
3	7/1/91	Jejunorectal anastomosis (60 cm)	15 (distal)	51	No (only hydroelectrolytic infusions, 2–4 days/week; HPN stopped 6/94)
4	12/22/92	Jejunotransverse anastomosis (30 cm)	12 (proximal)	35	Yes, partial* (HPN 4 days/week)
5	2/15/93	Jejunotransverse anastomosis (70 cm)	14 (distal)	26	No (HPN stopped 9/93; 100% oral nutrition)
6	2/11/94	Jejunocecal anastomosis (60 cm) Segmental transverse colon resection Definitive left colostomy	12 (distal)	7	Yes, partial* (died of pulmonary embolism; HPN 3 days/week)
7	2/8/95	Jejunotransverse anastomosis (25 cm)	8 (distal)	8	Yes, partial* (HPN 4 days/week)
8	12/11/95	Jejunotransverse anastomosis (40 cm)	10 (distal)	2	Yes, partial* (HPN 5 days/week)

HPN = home parenteral nutrition.
* Seven days/week before segmental reversal of the small bowel.

the care of patients with SBS. In addition, reconstructive surgical procedures such as SRSB, first proposed in the early 1960s, must be discussed today in light of the recent results reported for HPN and intestinal transplantation. HPN has been clearly demonstrated to be the most determinant technique responsible for prolonging the life of patients with SBS.[2,15] Since the 1970s, the feasability and safety of HPN has been demonstrated. The probability of survival was 80% and 62% at 2 and 5 years, respectively, in 217 nonmalignant patients receiving long-term HPN in whom 60% suffered from SBS.[2] Patients receiving long-term HPN are still exposed to catheter-related complications, bone disease, cholelithiasis, or liver failure.[15] Furthermore, HPN impairs work and social activities, and costs >$70,000/year.[2,18]

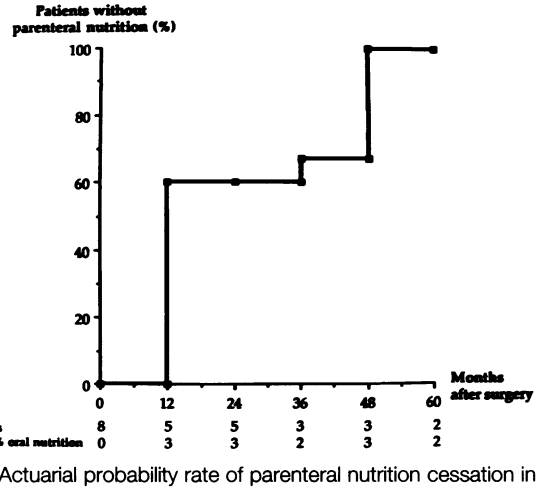

Figure 2. Actuarial probability rate of parenteral nutrition cessation in eight patients with SBS having undergone SRSB. SBS = short bowel syndrome; SRBS = segmental reversal of the small bowel.

To date, intestinal transplantation remains a difficult procedure, and carries high morbidity and mortality rates. Despite improvement in the control of graft rejection by FK506, ~40% of patients die within 2 years after transplantation, and 20% of the surviving patients have to resume HPN after graft enterectomy.[3] Obviously, recent reports of HPN may compare favorably with intestinal transplantation: among 41 patients younger than 60 years receiving HPN and presenting with very small bowel syndrome (<50 cm), who theoretically represent suitable candidates for small bowel transplantation, the probability of survival after 1 and 2 years was 98% and 90%, respectively.[2] Intestinal transplantation must stand the test of time before it can be proposed for all patients with SBS

(15). At the present time, for SBS patients who are HPN-dependent, intestinal transplantation should be considered as a life-saving procedure in cases where life-threatening HPN-related complications or associated liver failure occur, provided no other available alternative surgical treatment can be used.

Indeed, SRSB may act in SBS patients as an ileocolonic junction, prolonging transit time and contact between luminal nutrients and remnant mucosal surface. Experimentally, SRSB has been found to increase water, nitrogen, and fat absorption in dogs.[6] The antiperistaltic segment was observed to cause retrograde peristalsis and disrupt the motility of the proximal intestine. The disruption of the intrinsic nerve plexus slows distal myoelectrical activity.[19] Some 25 patients treated by SRSB have been reported so far.[4–13,15] Analysis of these cases appears difficult, because most of them are anecdotal, had in most reports short-term follow-up, and, had, in some patients, debatable indications (>1.5 m of remnant small bowel). Approximately 70% of patients appear to derive some benefits from SRSB. However, initial manometric abnormalities of proximal intestine were shown to attenuate, but not to disappear with time[4], and the initially increased absorption was no longer present 6 months after surgery.[5] These findings raised the issue of long-term function after SRSB. As we demonstrated, the beneficial effects of this surgery have been maintained for up to 9 years. It is indeed difficult to be sure that SRSB per se was the factor responsible for the weaning from HPN and not just intestinal adaptation. In this series, all the patients underwent SRSB at the time of intestinal continuity restoration. Thus, no comparison of intestinal function with intestinal continuity, but without SRSB, was available for the same patients. Only a long-term prospective study, comparing a sufficient number of patients with and without SRSB, would address this issue, which suggests the need to do SRSB in tertiary care centers. Nevertheless, this study provides arguments suggesting that SRSB per se plays a role in weaning from HPN. First, as we demonstrated in patient 1,[4] intestinal absorptive capacity reached subnormal values, allowing oral nutritional autonomy and demonstrating a delayed intestinal transit time, which extended for up to 9 years. Second, we and others have observed that the probability of weaning from long-term HPN in patients with a small bowel length ≤0.70 m and without the ileocolonic junction (as was the case with all of our patients) is very low[1,20]; in contrast, the probability of our patients weaning off HPN was 100% at 4 years.

The ideal segment length to be reversed seems to be 10 cm, because shorter segments may be inefficient in slowing transit time, whereas longer segments may create a clinical bowel obstruction syndrome. In addition, to achieve optimal benefit, the reversed segment should be located in the most distal part of the small bowel. The only patient in our series in whom proximal instead of distal SRSB was performed had a poor result after 35 months of follow-up. The main limitation of SRSB is the very short length of remnant small bowel, which may not allow the sacrifice of a 10-cm segment for reversal.[15] In our experience, SRSB proved feasible if remnant small bowel was 25 cm long, but was not indicated for a remnant longer than 1 m. Despite careful attention during the operation, SRSB has been shown to lead to risks of ischemia and anastomotic leakage.[15] No such complication was observed in the present series.

We do not recommend systematic prophylactic cholecystectomy at the time of SRSB. The risk of acute cholecystitis in patients with SBS receiving HPN is 21%.[21] Furthermore, because most of the patients have been previously operated several times before SRSB, cholecystectomy could be very difficult. Thus, we advice cholecystectomy only in patients who have had biliary symptoms or in whom sludge or lithiasis was diagnosed preoperatively. There is general agreement that SRSB should not be performed at the time of initial resection, because of the possibility of intestinal adaptation.[22] We performed both at the same time in one patient. However, in patients with very short remant small bowel and no ileocolonic junction, in whom there is no hope of early weaning off HPN, SRSB can be proposed at the time of intestinal continuity restoration. In patients older than 60 years, as in four of eight of our patients, for whom transplantation will be probably contraindicated, SRSB can be proposed, avoiding further surgery. Finally, we suggest that the SRSB procedure should be done first for younger patients, in whom intestinal transplantation is advocated, provided jejunal remnant length is present (i.e., ≥25 cm): if it fails to allow patients to wean off HPN, intestinal transplantation remains a possibility.

At least in adults, SRSB compares favorably with other reconstructive surgical procedures proposed for the treatment of SBS (i.e., colonic interposition, construction of valves, and small bowel tapering or lengthening). Proximal colonic interposition has been performed in 12 infants and in only 1 adult.[23] It may be a useful technique in patients when the small bowel is too short to be used for reversal. Poor results have been reported for antiperistaltic distal colonic interposition,[24] which resulted in increased morbidity, even though some improved absorption was obtained. The creation of intestinal valves by constricting intestine externally and intussuscepting an intestinal segment has also been proposed.[25] However, technical problems have led to inconsistent results.[24] Small bowel tapering or lengthening have been performed in a few adults.[15,16,22] Long-term complications of lengthening have included anastomotic stricture, fistula formation, and proximal intestinal dilatation.[26] Both procedures cannot be performed in cases of nondilated bowel.[1]

In conclusion, SRSB appears to be a suitable surgical procedure for patients with a very short bowel who are deemed to be dependent on HPN. It is an alternative to intestinal transplantation, provided it is used early in the course of SBS, before life-threatening HPN-related complications arise.

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